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Hugh Smith Lake Sockeye Salmon Adult and Juvenile Studies, 2009

by

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and

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

In 2009, we continued long-term population studies at Hugh Smith Lake that were designed to monitor the wild sockeye salmon stock and to assess the effects of lake stocking and rehabilitation efforts on this historically productive system. A sockeye salmon smolt abundance estimate, as well as smolt age and size information, was collected from 22 April to 7 June at the spring smolt weir, which was operated by a separate coho salmon coded-wire tagging project. Approximately 116,000 sockeye salmon smolt passed through the smolt weir, and the estimated freshwater age distribution of the smolt was 40% age 1, 59% age 2, and 1% age 3. From 16 June to 8 November we enumerated the adult salmon escapement through a weir, conducted a secondary mark-recapture estimate to confirm the weir count, and collected biological information to estimate the age, length, and sex composition of the sockeye salmon returning to Hugh Smith Lake. The 2009 weir count was 9,483 adult sockeye salmon; the sixth escapement in the past seven years to meet the optimal escapement goal range of 8,000–18,000 adult sockeye salmon. Age-1.3 fish represented the dominate age class amongst a spawning population composed of 42% 2-ocean and 58% 3-ocean fish. Peak foot survey counts in the two primary spawning tributaries were 1,496 fish in Buschmann Creek on 30 August and 162 fish in Cobb Creek on 12 September 2009. No area closures or time restrictions were implemented in nearby commercial fisheries as projected returns of Hugh Smith Lake sockeye salmon were above the lower threshold of the escapement goal throughout the season.

Key words: escapement, optimal escapement goal, Hugh Smith Lake, lake stocking, mark-recapture, sockeye salmon, *Oncorhynchus nerka*, stock of concern.

INTRODUCTION

In 2003, the Alaska Board of Fisheries adopted Hugh Smith Lake sockeye salmon (*Oncorhynchus nerka*) as a stock of management concern (5 AAC 39.222), due to a long-term decline in escapement (Geiger et al. 2003). Escapements averaged 17,500 during the 1980s, 12,000 during the 1990s, and only 5,000 from 1998 to 2002. The Board of Fisheries adopted an action plan to rebuild the sockeye salmon run to levels that would meet the escapement goal range of 8,000–18,000 adult sockeye salmon (Hugh Smith Lake Sockeye Salmon Action Plan, Final Report to the Board of Fish, RC-106, February 2003). The escapement goal is an *optimal* escapement goal that includes spawning salmon of wild and hatchery origin (5 AAC 33.390). The action plan directed the Alaska Department of Fish and Game (ADF&G) to review stock assessment and rehabilitation efforts at the lake and contained measures to reduce commercial harvests of Hugh Smith Lake sockeye salmon when the escapement was projected to be below the lower end of the escapement goal range. The rehabilitation effort included a hatchery stocking program in which sockeye salmon fry were fed to pre-smolt size from late May through July while rearing in net-pens in the lake. Eggs for this program were collected at the mouth of Buschmann Creek, which is one of the primary spawning tributaries for sockeye salmon in Hugh Smith Lake. This stocking of pen-reared fry occurred from 1999 to 2003, and all released fry had thermal otolith marks. The last adult fish from this stocking program returned to the lake as 3-ocean fish in 2007.

Total escapements of adult sockeye salmon at Hugh Smith Lake have improved steadily since reaching a low of 1,100 in 1998, and escapements surpassed the upper end of the escapement goal range from 2003 to 2007 (Piston 2008). Although large numbers of fish were passed through the counting weir in these recent years, the behavior and distribution of the stocked portion of the run within the system indicated that many of these fish did not fully contribute to juvenile production (Geiger et al. 2005, Piston et al. 2007, Piston 2008 and 2009). From 2002 to 2007, stocked fish made up a significant portion of the escapement at the two primary tributaries of Hugh Smith Lake: an average of 22% at Buschmann Creek and 68% at Cobb Creek, with an additional large, but unknown number of stocked sockeye salmon attempting to spawn in unsuitable habitat at the outlet of the lake (Piston et al. 2007, Piston 2008). Spring smolt counts from 2005 to 2008 showed no sign of increase over the preceding three years despite a dramatic increase in brood year escapements beginning in 2003 (Piston 2008).

Estimates for the wild portion of the spawning escapement have also shown improvement in recent years. In 2005 and 2006, escapements of wild sockeye salmon reached the escapement goal for the first time since 1997 (Piston et al. 2007). Because of the positive trends in escapement through 2005, the Hugh Smith Lake sockeye salmon stock was de-listed as a stock of management concern at the 2006 Board of Fisheries meeting. In 2007, the wild portion of the escapement was within the escapement goal range, but in 2008 it was less than half of the lower bound of the escapement goal range of 8,000–18,000 fish. However, the poor escapement to Hugh Smith Lake in 2008 appeared to be associated with conditions that affected salmon runs regionwide, rather than from conditions within Hugh Smith Lake and its tributaries (Piston 2009). Sockeye salmon escapements to Southeast Alaska were extremely poor in 2008 and the region-wide harvest of sockeye salmon was the lowest since Alaska statehood (Eggers et al. 2008).

From 2004 to 2007, studies were conducted to identify factors limiting the productivity of sockeye salmon at various stages of their life history within Hugh Smith Lake. Total juvenile sockeye salmon production, mid-summer-to-spring survival rates of sockeye salmon fry, fry emigration timing from Buschmann and Cobb creeks, habitat changes within Buschmann Creek, and zooplankton production within the lake were examined (Piston et al. 2006 and 2007). In addition, a Dolly Varden predation study was conducted at the spring smolt weir in 2007 (Piston 2008). These studies did not identify any factors in the freshwater environment that would result in reduced juvenile sockeye salmon survival rates.

In 2009, we continued operating the adult salmon counting weir at Hugh Smith Lake. Along with counting fish by species through the weir, we conducted a secondary mark-recapture estimate on sockeye salmon to ensure we obtained a reliable escapement estimate in case the weir failed during the season. Age, sex, and length information was collected from a sub-set of the sockeye salmon passed through the weir and live counts of spawning salmon were conducted on the two primary inlet streams in conjunction with mark-recapture efforts. Sockeye salmon smolt numbers were estimated at the spring smolt weir, which is operated by a separate coded-wire tagging coho salmon (*O. kisutch*) project, and age, sex, and length information was collected from a sub-set of the sockeye salmon smolt.

STUDY SITE

Hugh Smith Lake (55° 06’ N, 134° 40’ W; Orth 1967) is located 97 km southeast of Ketchikan, on mainland Southeast Alaska, in Misty Fjords National Monument (Figure 1). The lake is organically stained, with a surface area of 320 ha, mean depth of 70 m, maximum depth of 121 m, and volume of $222.7 \cdot 10^6$ m^3 (Figure 2). The lake empties into Boca de Quadra inlet via 50-m-long Sockeye Creek (ADF&G Anadromous Waters Catalog number 101-30-10750). Sockeye salmon spawn in two inlet streams: Buschmann Creek flows northwest 4 km to the head of the lake (ADF&G Anadromous Waters Catalog number 101-30-10750-2006, Beaver Pond Channel 101-30-10750-3003); and Cobb Creek flows north 8 km to the southeast head of the lake (ADF&G Anadromous Waters Catalog number 101-30-10750-2004, Figure 2). Cobb Creek has a barrier to anadromous migration approximately 0.8 km upstream from the lake. Hugh Smith Lake is meromictic, and a layer of saltwater located below 60 m does not interact with the upper freshwater layer of the lake.

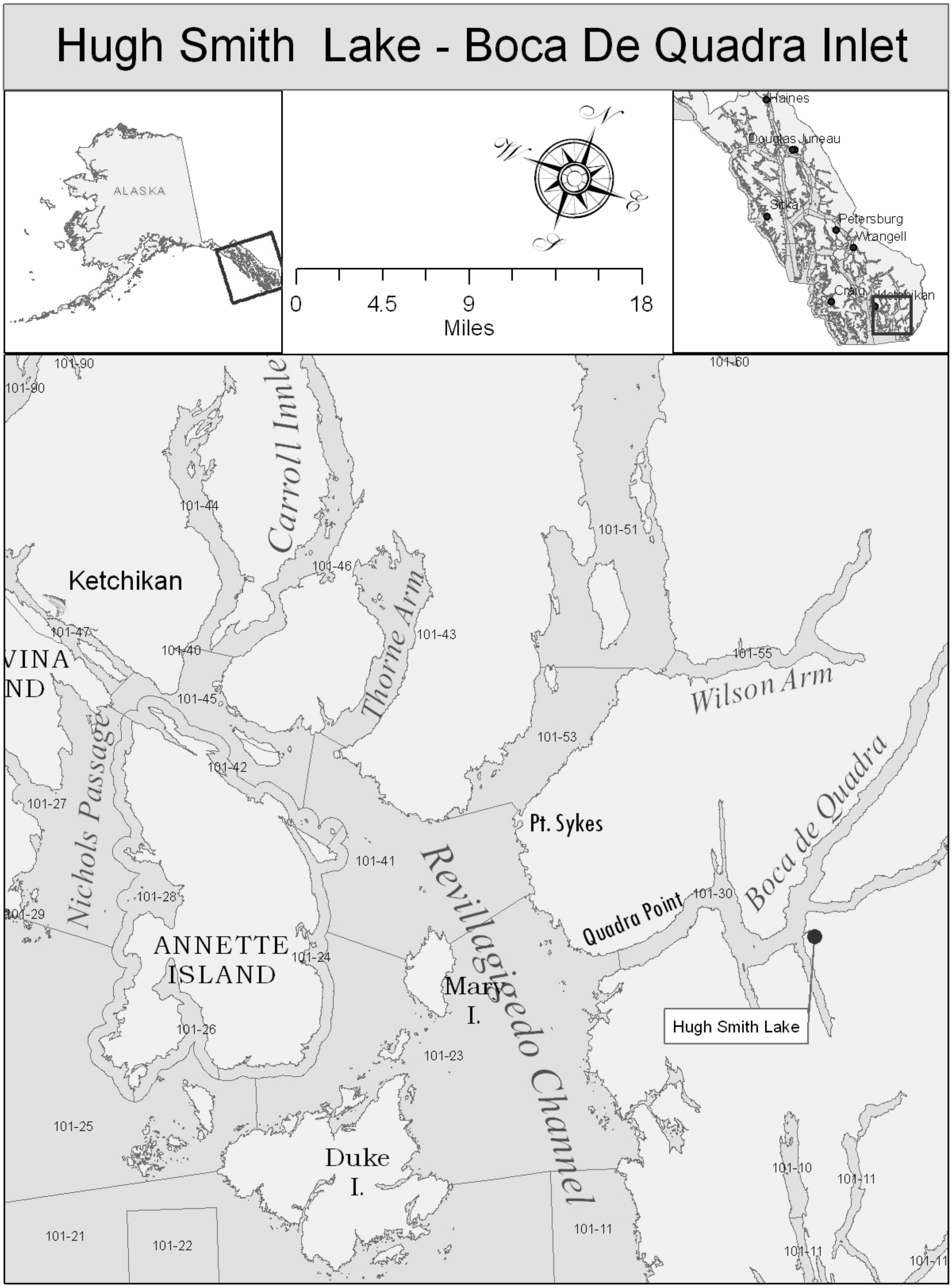

Figure 1.–The location of Hugh Smith Lake in Southeast Alaska.

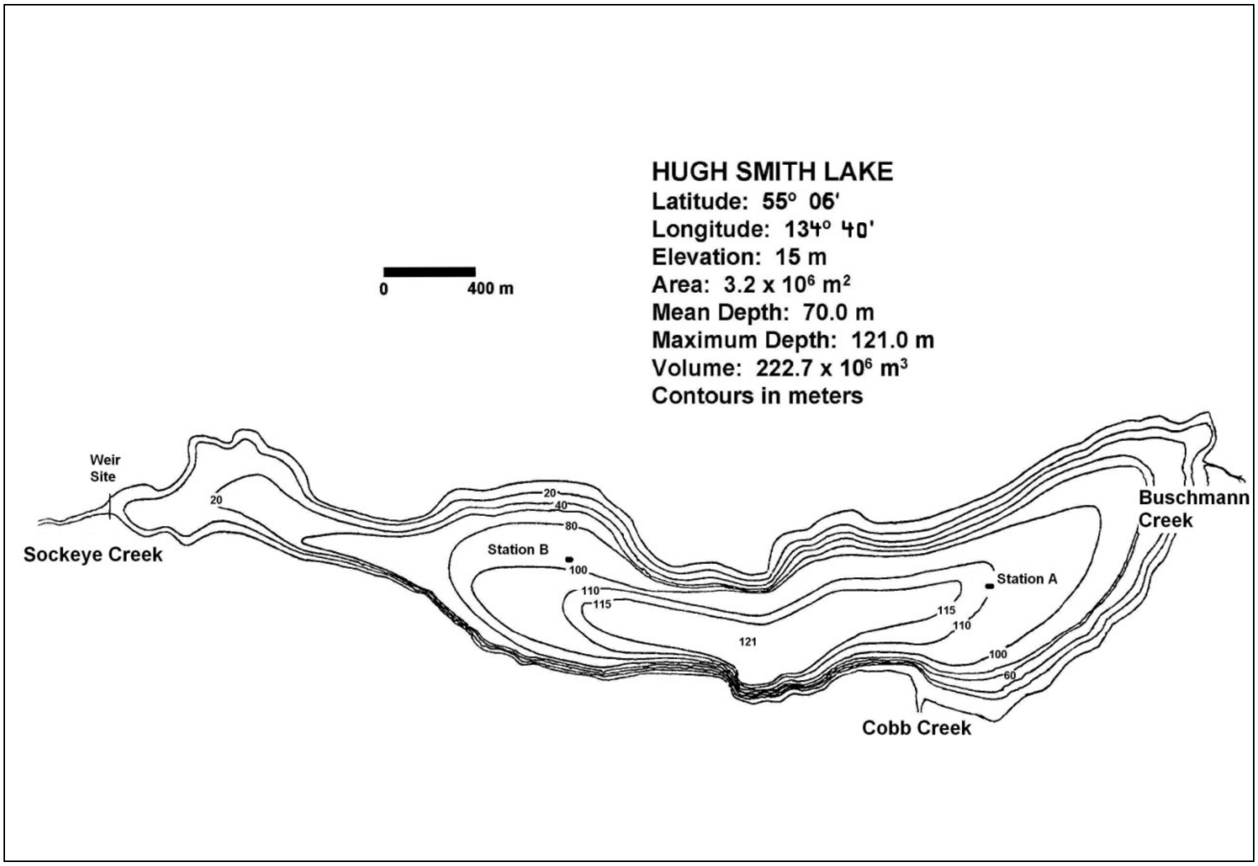

Figure 2.–Bathymetric map of Hugh Smith Lake, Southeast Alaska, showing the location of the weir site, stations A and B, the primary inlet streams, and other features of the lake system.

METHODS

SMOLT PRODUCTION

A smolt weir was used from 1982 to 2009 to sample and count coho and sockeye salmon smolt emigrating from Hugh Smith Lake (see Shaul et al. 2009 for a physical description of weir). The smolt weir was operated from 22 April to 7 June in 2009. Fish were counted through the weir by species and scale samples and length-weight data were collected from sockeye salmon smolt. Scale samples were collected at a rate of 16 fish per day when fewer than 100 fish were captured at the weir each day, and 28 fish per day when more than 100 fish were captured per day. The length (snout-to-fork in mm) and weight (to the nearest 0.1 g) was recorded for each fish sampled. A preferred-area scale smear (Clutter and Whitesel 1956) was taken from each fish and mounted on a 2.5 cm × 7.5 cm glass slide, four fish per slide. A video-linked microscope was used to age sockeye salmon smolt scales at the Ketchikan office.

We know that total smolt weir counts have tended to underestimate the true smolt population size, due to fish passing before and after the weir was installed and because fish escaped past the weir uncounted. An unknown, but presumably small number of smolt also pass through a small opening designed to allow free upstream passage of adult steelhead. Hugh Smith Lake coho salmon smolt tagging data from 1982–2006 showed that capture rate at the smolt weir was highly variable, ranging from 14% to 84%. In recent years, extra effort has been made to tighten the weir and prevent smolt from passing under or around it uncounted. From 1996–2006, these efforts have improved the capture efficiency to an average of 70% for coho salmon smolt (Shaul et al. 2009).

ADULT ESCAPEMENT

Weir Counts

ADF&G operated an adult salmon counting weir at the outlet of the lake, approximately 50 m from saltwater, from 1967 to 1971, and also from 1981 to 2009. The weir is an aluminum bi-pod, channel-and-picket design, with an upstream trap for enumerating and sampling salmon. The integrity of the weir was verified by periodic underwater inspections and a secondary mark-recapture study (see below). The weir was operated from mid-June to early November in 2009 and fish were counted through the weir in a way that minimized handling as much as possible.

Adjacent to the primary upstream trap, we built a secondary trap/counting station designed to allow for free passage of fish into the lake, while also allowing us to quickly close the trap when a coho salmon or other fish of interest entered. It was very important that all coho salmon were examined for missing adipose fins, which indicated the presence of coded-wire tags. Hugh Smith Lake coho salmon are an important indicator stock in southeast Alaska (Shaul et al. 2005, 2009). The secondary modified trap allowed us to continue passing a portion of the sockeye salmon freely through the pickets throughout the season while continuing to meet the goals of the ongoing coho salmon study at the lake. We placed a white board on the bottom of the streambed at the secondary trap/counting station to aid in fish identification. Fish passage was also monitored with a video camera so that in the event we failed to stop a coho salmon we were still able to identify it as adipose-clipped or unclipped. In addition, during periods of low stream flow we would apply 4–6 mil plastic sheeting to the face of the weir to concentrate stream flow through the fish passing station and trap to reduce the incidence of fish remaining behind the weir for extended periods.

Mark Recapture

As in past years, we conducted a two-sample mark-recapture population study, in conjunction with weir operations, to estimate the total spawning population of sockeye and coho salmon at Hugh Smith Lake during the 2009 season. These studies helped to determine if fish passed by the weir uncounted, or if sockeye salmon entered the lake before the weir was fish tight in mid-June. Adult sockeye salmon (fish >400 mm in length) were marked at a rate of 10% with a readily identifiable fin clip at the weir. Fish that were to be marked were dip-netted from the trap, anesthetized in a clove oil solution (Woolsey et al. 2004), fin-clipped, scale-sampled, and released upstream next to the trap to recover. Fish that did not appear healthy were not marked with a fin-clip. The population of fish passing through the weir was stratified through time on the following schedule: right ventral fin clip, 16 June–18 July; left ventral fin clip, 19 July–15 August; and partial dorsal fin clip, 16 August–8 November. We did not conduct a mark-recapture study for jack sockeye salmon (<400 mm) because most of them pass freely through the weir pickets. In the past, we have not been able to mark and recover enough fish to obtain a valid population estimate for jacks.

We used Stratified Population Analysis System (SPAS) software (Arnason et al. 1996) to generate mark-recapture estimates of the total spawning population of sockeye salmon. SPAS was designed for analysis of two-sample mark-recapture data where marks and recoveries take place over a number of strata. This program was based on work by Chapman and Junge (1956), Darroch (1961), Seber (1982), and Plante (1990). We used this software to calculate: 1) maximum likelihood (ML) Darroch estimates and pooled-Petersen (Chapman's modified) estimates, and their standard errors; 2) X^2 tests for goodness-of-fit based on the deviation of predicted values (fitted by the ML Darroch estimate) from the observed values; and 3) two X^2 tests of the validity of using fully pooled data—a test of complete mixing of marked fish between release and recovery strata, and a test of equal proportions of marked fish in the recovery strata. We chose full pooling of the data (i.e., the pooled-Petersen estimate) if the result of either of these tests was not significant ($p>0.05$). Our goal was to estimate the escapement such that the coefficient of variation was no greater than 15% of the point estimate. The manipulation of release and recovery strata in calculating estimates (the method used in SPAS) was presented and discussed at length by Schwarz and Taylor (1998).

We deemed the weir count to be "verified" if it fell within the 95% confidence interval of the mark-recapture estimate of adult sockeye salmon, in which case the weir count was entered as the official escapement estimate. This was the same criterion as used in previous years (Geiger et al. 2003). The escapement goal was judged to have been met if the weir count was within 8,000 to 18,000 adult sockeye salmon and the weir count was within the 95% confidence interval of the mark-recapture estimate for adult sockeye salmon. The escapement goal would be deemed to have not been met if the weir count and the mark-recapture estimates were both outside of the escapement goal range. In the case where one or the other estimate fell within the escapement goal range, the weir count would be used, unless the weir count was below the lower end of the 95% confidence interval of the mark-recapture estimate. Prior to the study we agreed to use the mark-recapture "point" estimate, and not one or the other end of a confidence interval, for the purpose of judging the escapement objective.

Adult Length, Sex, and Scale Sampling

The age composition of adult sockeye salmon at Hugh Smith Lake was determined from a minimum of 600 scale samples collected from live fish at the weir. The sample size was chosen based on work by Thompson (1992) for calculating a sample size for estimating several proportions simultaneously. A sample of 510 fish was determined to be the sample size needed to ensure that the estimated proportions of each of the age classes of sockeye salmon returning to Hugh Smith Lake would be within 5% of the true value 95% of the time. We increased our sampling goal to ensure we met the sample size target even if 15% of our scale samples were unreadable. We began the season by taking scale samples at a rate of 1 in 10 (10%). The sex and length (mideye-to-fork to the nearest mm) was recorded for each fish sampled. One scale was taken from the preferred area (INPFC 1963), mounted on a gum card, and prepared for analysis as described by Clutter and Whitesel (1956). Scale samples were analyzed at the ADF&G salmon-aging laboratory in Douglas, Alaska. The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week were calculated using equations from Cochran (1977; Appendix A).

Escapement Counts

The number of live and dead salmon in the creek was estimated, by species, during each survey of Buschmann and Cobb creeks. Cobb Creek was surveyed from the mouth to the barrier falls (0.42 miles; 55 05.35 N, 130 38.673 W). Buschmann Creek was typically surveyed to the top of the Hatchery Channel on the right fork, and to the beaver ponds on the left fork (Figure 3). We attempted to survey all of Buschmann Creek's stream channels at least twice near the peak of the run.

What we have generally referred to as Buschmann Creek actually consists of two separate creeks, draining two separate valleys, which come together in their lower reaches. The stream flowing in from the valley to the southeast is Buschmann Creek (ADF&G Anadromous Waters Catalog number 101-30-10750-2006), and the tributary flowing out of the northeast valley that meets Buschmann Creek at what we call the Main Fork is referred to as the Beaver Pond Channel (ADF&G Anadromous Waters Catalog number 101-30-10750-3003; Figure 3). The Beaver Pond Channel is so named because there have consistently been one or more beaver dams and ponds along its length.

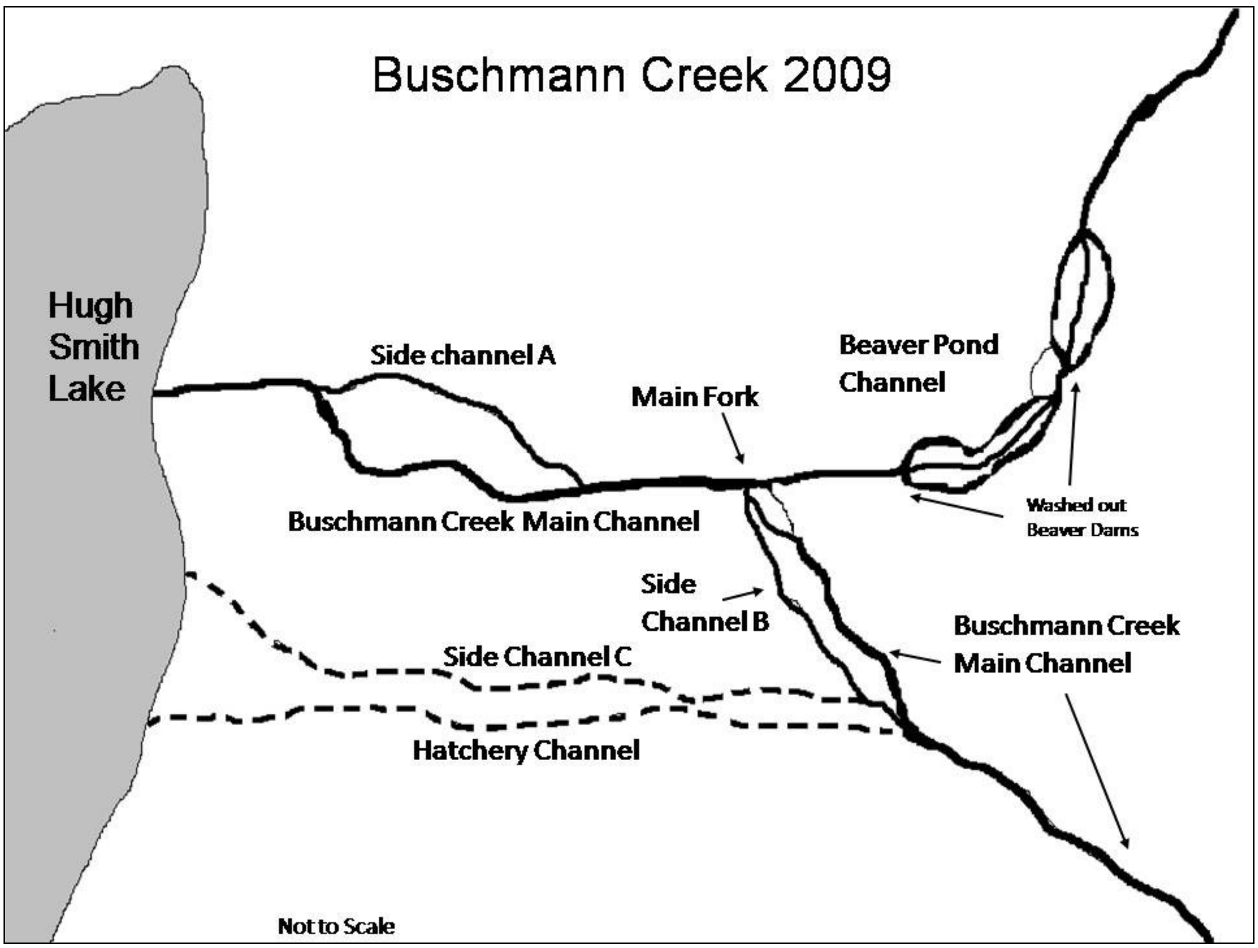

Figure 3.–Schematic diagram of the main channels of lower Buschmann Creek, as of November 2009.

RESULTS

SMOLT PRODUCTION

A total of 116,000 sockeye salmon smolt were counted through the smolt weir between 22 April and 7 June (Table 1). The lake was still completely ice covered during the third week of April and remained partly ice covered through the first week of May. Water surface temperatures remained at, or below, 4° C until approximately mid-May. The first day that >1,000 sockeye salmon smolt passed through the smolt weir was 18 May, a day in which water surface temperatures increased from 5.5° C to over 7° C. Emigration remained strong through early June, with large movements of sockeye salmon smolt on 22 and 30 May (19,700 and 21,500 smolt respectively). Although the weir was operated for an extra week due to the late timing of the smolt emigration, approximately 500 smolt were passed each day during the final two days of the smolt weir operation on 6 and 7 June. Therefore, it is likely that thousands of smolt left the lake after the smolt weir was removed.

We sampled 698 sockeye salmon smolt for scales and determined that the age composition, weighted by week, was 40.1% age 1, 59.2% age 2, and 0.7% age 3 (Figure 4, Table 1). This was the first year since 1995 that the proportion of age-2 smolt was greater than the proportion of age-1 smolt at Hugh Smith Lake (Figure 4). The mean lengths of the smolt, by age class, were 72 mm (age 1), 96 mm (age 2), and 103 mm (age 3). The mean weights were 3.3 grams (age 1), 7.4 grams (age 2), and 9.2 grams (age 3, Table 2).

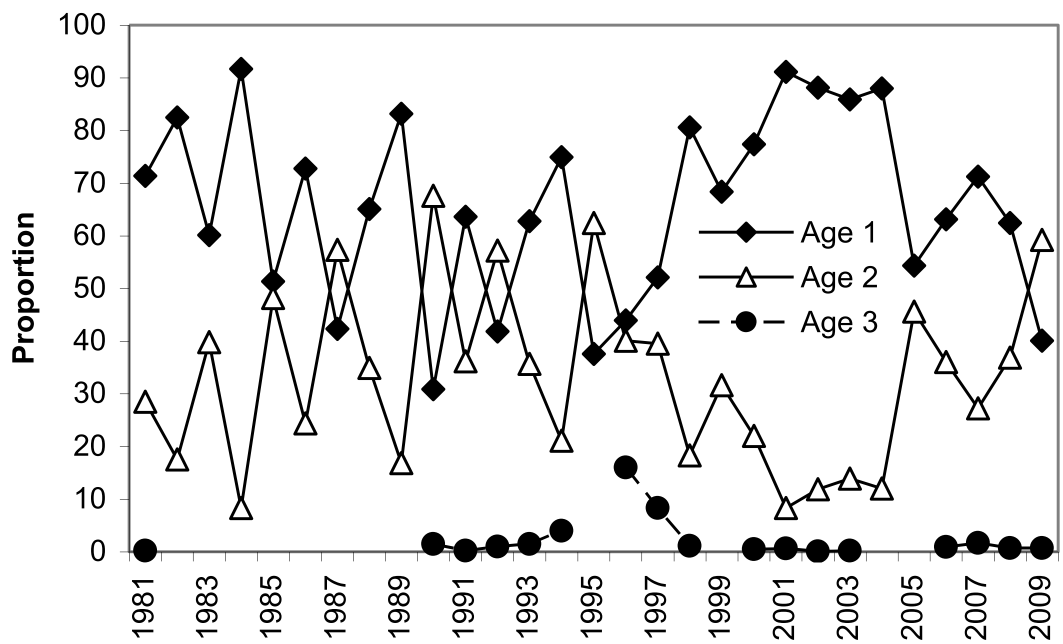

Figure 4.–Age composition of sockeye salmon smolt at Hugh Smith Lake, 1981–2009.

Table 1.–Hugh Smith Lake weir counts of sockeye salmon smolt by smolt year, and stocked fry and pre-smolt releases by year of release, 1981–2009. Proportions of stocked and wild smolt were determined from otolith samples.

Release Year	Hatchery Release Numbers	Release Type	Smolt Year	Total Smolt Counted	Freshwater Age Percent of Total Age 1	Age 2	Age 3	Stocked Smolt Counted	Wild Smolt Counted	Percent Stocked Smolt
			1981	319,000	71%	29%	0%			
			1982	90,000	83%	18%	0%			
			1983	77,000	60%	40%	0%			
			1984	330,000	92%	8%	0%			
			1985	40,000	51%	48%	1%			
			1986	**58,000**[c]	73%	24%	3%			
1986	273,000	Unfed Fry	1987	104,000	42%	57%	1%			
1987	250,000	Unfed Fry	1988	54,000	65%	35%	0%			
1988	1,206,000	Unfed Fry	1989	427,000	83%	17%	0%			
1989	532,800	Unfed Fry	1990	137,000	31%	68%	2%			
1990	1,480,800	Unfed Fry	1991	75,000	64%	36%	0%			
1991			1992	15,000	42%	57%	1%			
1992	477,500	Fed Fry	1993	36,000	63%	36%	2%			
1993			1994	43,000	75%	21%	4%			
1994	645,000	Unfed Fry	1995	19,000	38%	62%	0%			
1995	418,000	Unfed Fry	1996	16,000	44%	40%	16%			
1996	358,000	Unfed Fry/ Pre-Smolt[a]	1997	44,000	52%	40%	8%			
1997	573,000	Unfed Fry	1998	65,000	81%	18%	1%	30,000	34,000	47%
1998	0		1999	42,000	68%	32%	0%	3,000	39,000	4%
1999	202,000	Pre-smolt[b]	2000	72,000	77%	22%	1%		---No data---	
2000	380,000	Pre-smolt[b]	2001	190,000	91%	8%	1%	145,000	44,000	77%
2001	445,000	Pre-smolt[b]	2002	297,000	88%	12%	0%	163,000	134,000	55%
2002	465,000	Pre-smolt[b]	2003	261,000	86%	14%	0%	185,000	76,000	71%
2003	420,000	Pre-smolt[b]	2004	364,000	88%	12%	0%	170,000	194,000	47%
2004	0		2005	77,000	54%	46%	0%		77,000	
2005	0		2006	119,000	63%	36%	1%		119,000	
2006	0		2007	89,000	71%	27%	2%		89,000	
2007	0		2008	59,000	62%	37%	1%		59,000	
2008	0		2009	116,000	40%	59%	1%		116,000	

[a] In 1996, Southern Southeast Regional Aquaculture Association released 251,123 unfed fry into the lake in May and 106,833 pre-smolt in October. All fish from those releases were otolith marked.

[b] From 1999–2003, fry were pen-reared at the outlet of the lake beginning in late May and released as pre-smolt in late July and early August. All fish from those releases were otolith marked.

[c] The smolt weir count for 1986 that was reported in Geiger et al. (2003), Piston et al. (2006), and Piston et al. (2007) was actually an estimate based on a hydroacoustic survey. A section of the smolt weir was removed from 27–31 May, and researchers at the time probably assumed the hydroacoustic estimate of 373,000 was a better estimate. We judged that this estimate should not be compared directly to other smolt weir estimates and included the smolt weir count for 1986 in this report.

Table 2.–Weighted lengths and weights of sockeye salmon smolt at Hugh Smith Lake by age class, 2009.

	Age Class		
	1	**2**	**3**
Number	291	403	4
Mean Length (mm)	72	96	103
Standard Error (mm)	0.4	0.5	3.6
Maximum Length (mm)	90	128	112
Minimum Length (mm)	54	70	94
Mean Weight (g)	3.3	7.4	9.2
Standard Error (g)	0.1	0.1	0.8
Maximum Weight (g)	6.1	15.7	11.4
Minimum Weight (g)	1.3	2.8	7.4

ADULT ESCAPEMENT

The adult weir was fish-tight from 16 June to 8 November and during that time period we passed 9,483 adult sockeye salmon and 301 jacks into the lake. There were no handling mortalities observed at the weir in 2009. The mid-point of the run occurred on 23 July, which is earlier than the average over the previous 27 years (historic mean = 6 August), and the 75th percentile of the run occurred on 11 August (historic mean = 23 August). Peak counts of adult sockeye salmon on the spawning grounds were 1,496 live fish in Buschmann Creek (30 August; Table 3) and 162 live fish in Cobb Creek (12 September; Table 4). There were no stocked fish returning to the system in 2009 and the escapement goal range of 8,000–18,000 sockeye salmon was met with wild fish for the fourth time in the last five years (Figure 5, Appendix B).

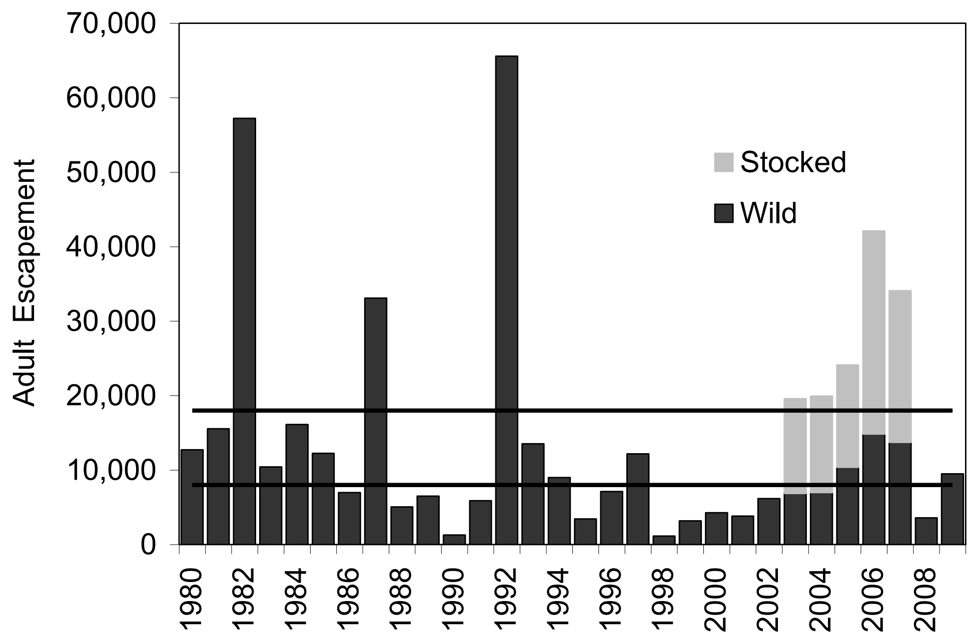

Figure 5.–Annual sockeye salmon escapement at Hugh Smith Lake, 1980–2009. The black horizontal lines show the current optimal escapement goal range of 8,000–18,000 adult sockeye salmon. This escapement goal range includes both wild and hatchery stocked fish. From 2003 to 2007, the bars are divided to show our estimate of wild (black) and stocked fish (gray). Fry stocked from 1986 to 1997 were thought to have experienced very low survival rates, with few surviving to emigrate from the lake (Geiger et al. 2003).

Table 3.–Counts of adult sockeye salmon in Buschmann Creek by stream section, 2009. Blank cells indicate that the section was not surveyed on the corresponding date. Surveys conducted in the "Beaver Pond Channel" were of varying length and should not be directly compared between dates.

Date	**17-Aug**	**17-Aug**	**22-Aug**	**22-Aug**	**30-Aug**	**30-Aug**	**4-Sep**	**4-Sep**	**8-Sep**	**8-Sep**	**12-Sep**	**12-Sep**	**13-Sep**	**13-Sep**	**28-Sep**	**28-Sep**	**5-Oct**	**5-Oct**	**20-Oct**	**20-Oct**	**24-Oct**	**24-Oct**
Condition	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**
Mouth Estimate	200	0	350	0			500	4	2000	5			2000	2	110	10	20	8	1	0		
Main Channel	45	0	194	2	645	2	393	50	381	28	406	30	708	10	260	30	29	3	45	0	22	0
Side Channel A	7	0	63	2	189	4	158	26	328	27	199	20	230	9	62	10	21	0	27	0	7	0
Side Channel B					2	1			109	2	32	4			19	5	1	1				
Beaver Pond Ch.					222	0							465	15	70	15	1	0				
Fork to Hatchery Ch.	8	0	79	0	438	3	244	25	643	20	838	28			96	10	24	1				
Stream Total	60	0	336	4	1496	10	795	101	1461	77	1475	82	1403	34	507	70	76	5	72	0	29	0

Table 4.–Counts of adult sockeye salmon in Cobb Creek, 2009. Each survey was conducted from the mouth to the barrier falls and covered all available spawning habitat within the creek.

Date	**26-Aug**	**26-Aug**	**1-Sep**	**1-Sep**	**6-Sep**	**6-Sep**	**12-Sep**	**12-Sep**	**26-Sep**	**26-Sep**	**2-Oct**	**2-Oct**	**16-Oct**	**16-Oct**
Condition	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**
Mouth Estimate	80	0	100	0	60	1	100	2			0	0	0	0
Stream Count	51	0	92	0	109	11	162	10	46	2	18	13	0	1

In 2009, a total of 949 adults were marked at the weir with different fin clips over three marking strata. Between 18 June and 18 July, 316 adult sockeye salmon were marked with a right ventral fin clip. From 19 July to 15 August, 564 adult sockeye salmon were marked with a left ventral fin clip, and from 16 August to 8 November, 69 adult sockeye salmon were marked with a partial dorsal fin clip. Recapture sampling on the spawning grounds was conducted over the course of the entire spawning season, from 17 August to 17 October (Table 5). We also sampled all dead fish that washed up on the weir through 27 October (Table 5). A total of 1,271 fish were sampled for fin clips, of which 123 were marked (Table 5). The result of the X^2 test of complete mixing of marked fish between the marking and recovery events was significant (p<0.01), but the result of the test for equal proportions of marked fish on the spawning grounds was not significant (p=0.10), therefore we used the pooled-Petersen estimate. Our final estimate was 9,744 (SE=772; 95% CI=8,231 to 11,257) adult sockeye salmon (Appendix C). The weir count of 9,483 fell within the 95% confidence interval of the mark-recapture estimate so we deemed the weir count to be verified. The coefficient of variation of 8% met our objective of a coefficient of variation of no greater than 15%. Again, we did not conduct a mark-recapture study on sockeye jacks in 2009 because in past years we have been unable to mark and recover enough fish to obtain a reliable population estimate.

Table 5.–Daily number of marked fish recovered by release strata and total number of carcasses sampled for marks for the adult sockeye salmon mark-recapture study, 2009.

		Number of Marked Fish			Number	Total Number
Date	**Sampling Area**	**Left Ventral**	**Right Ventral**	**Dorsal**	**Unmarked**	**Sampled**
17-Aug	Buschmann Creek	0	0	0	25	25
22-Aug	Buschmann Creek	1	14	0	115	130
26-Aug	Buschmann Creek	1	4	0	64	69
30-Aug	Buschmann Creek	2	2	0	35	39
1-Sep	Cobb Creek	2	0	0	11	13
1-Sep	Buschmann Creek	7	4	0	175	186
4-Sep	Buschmann Creek	12	22	0	308	342
6-Sep	Cobb Creek	0	2	0	37	39
7-Sep	Buschmann Creek	3	3	0	72	78
8-Sep	Buschmann Creek	4	2	0	63	69
12-Sep	Cobb Creek	1	1	0	14	16
12-Sep	Buschmann Creek	4	5	0	100	109
13-Sep	Buschmann Creek	5	1	0	23	29
23-Sep	Weir	1	0	0	2	3
24-Sep	Weir	0	0	0	1	1
25-Sep	Weir	0	0	0	1	1
26-Sep	Weir	1	0	0	0	1
26-Sep	Cobb Creek	0	0	0	4	4
28-Sep	Weir	0	0	0	1	1
28-Sep	Buschmann Creek	8	1	1	57	67
29-Sep	Weir	0	0	0	1	1
2-Oct	Cobb Creek	0	1	0	2	3
5-Oct	Buschmann Creek	4	1	2	35	42
17-Oct	Buschmann Creek	0	0	1	1	2
27-Oct	Weir	0	0	0	1	1
	Total	56	63	4	1,148	1,271

The age composition of adult sockeye salmon, based on scale data, was 42% 2-ocean and 58% 3-ocean fish, with age-1.3 fish representing the dominant age class in 2009 (Table 6, Figure 6, Appendix D). The estimated number of 2-ocean fish in the escapement (3,995 fish), was one of the largest returns for this age class since 1980 (Figure 7). Five of the six years with larger escapements of 2-ocean fish (2002–2006) were years when pen-reared sockeye salmon returned to Hugh Smith Lake. During that time period, estimated escapements of 2-ocean fish averaged over 10,000 fish (Appendix D). If we consider years not influenced by fish returning from the recent stocking program, the 2009 escapement of 2-ocean fish was the second largest since 1980. The estimated number of 3-ocean fish in the escapement was 5,488 fish in 2009.

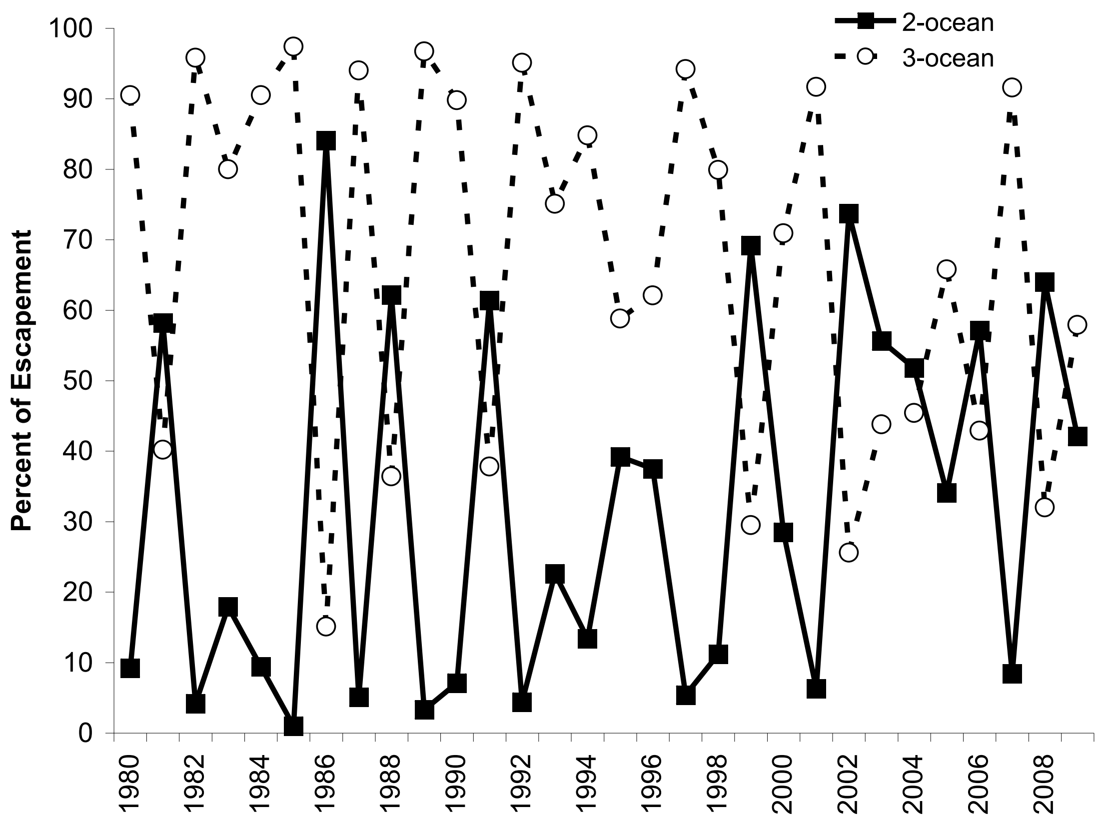

Figure 6.–Annual proportions of 2-ocean and 3-ocean aged sockeye salmon in the Hugh Smith Lake escapement, 1982–2009.

Table 6.–Age composition of the 2009 adult sockeye salmon escapement at Hugh Smith Lake based on scale samples, weighted by statistical week.

		Age Class				
Stat Week		**1.2**	**2.2**	**1.3**	**2.3**	**Total**
25-26	Sample Size	10	2	9	2	23
	Esc. Age Class	124	25	112	25	
	Proportion	43%	9%	39%	9%	
	SE of %	10%	6%	10%	6%	
27	Sample Size	15	3	43	4	65
	Esc. Age Class	164	33	470	44	
	Proportion	23%	5%	66%	6%	
	SE of %	5%	2%	6%	3%	
28	Sample Size	37	12	78	11	138
	Esc. Age Class	397	129	837	118	
	Proportion	27%	9%	57%	8%	
	SE of %	4%	2%	4%	2%	
29	Sample Size	24	8	27	4	63
	Esc. Age Class	258	86	291	43	
	Proportion	38%	13%	43%	6%	
	SE of %	6%	4%	6%	3%	
30	Sample Size	49	26	92	18	185
	Esc. Age Class	573	304	1076	210	
	Proportion	26%	14%	50%	10%	
	SE of %	3%	2%	4%	2%	
31	Sample Size	12	9	25	6	52
	Esc. Age Class	147	111	307	74	
	Proportion	23%	17%	48%	12%	
	SE of %	6%	5%	7%	4%	
32	Sample Size	1		4	2	7
	Esc. Age Class	19		76	38	
	Proportion	14%		57%	29%	
	SE of %	14%		20%	18%	
33	Sample Size	35	31	55	23	144
	Esc. Age Class	661	586	1039	434	
	Proportion	24%	22%	38%	16%	
	SE of %	3%	3%	4%	3%	
34	Sample Size	1	10	8	3	22
	Esc. Age Class	21	211	169	63	
	Proportion	5%	45%	36%	14%	
	SE of %	4%	11%	10%	7%	
35-41	Sample Size	2	5	1	2	10
	Esc. Age Class	42	104	21	42	
	Proportion	20%	50%	10%	20%	
	SE of %	13%	16%	10%	13%	
Total	Escapement by Age Class	2,407	1,588	4,397	1,091	9,483
	SE of Number	40	36	80	18	
	Proportion by Age Class	25%	17%	46%	12%	
	SE of %	0%	0%	1%	0%	
	Sample Size	186	106	342	75	709

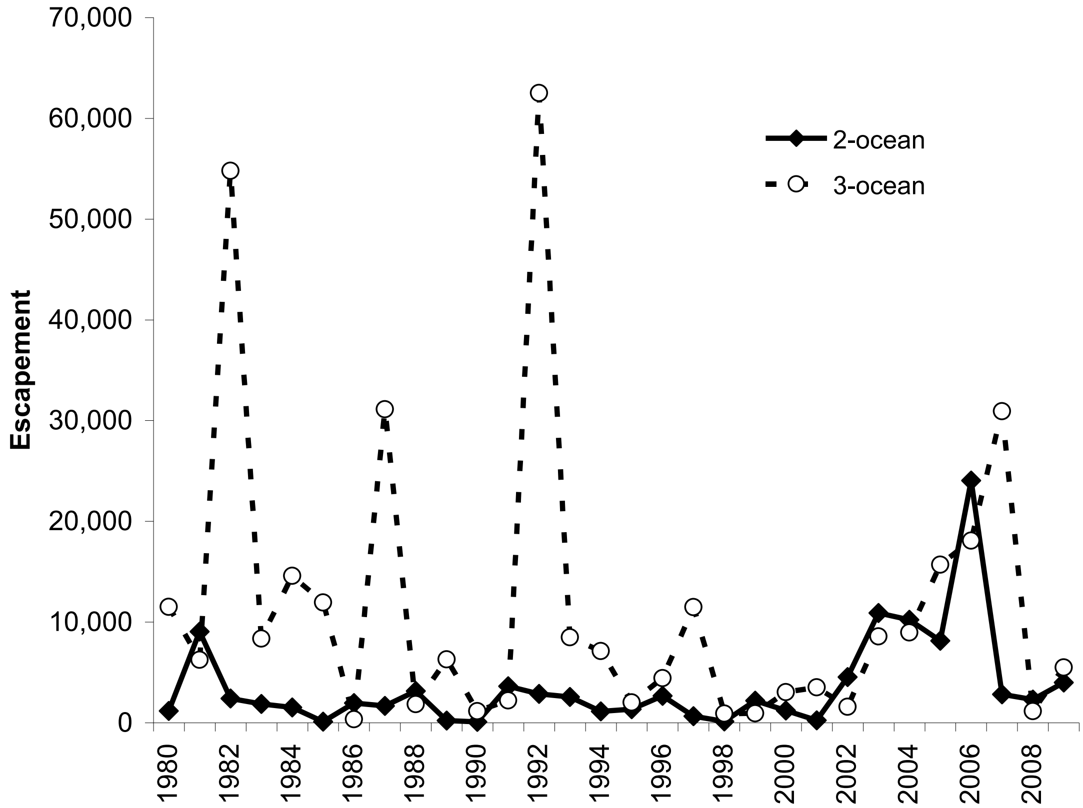

Figure 7.–Annual numbers of 2-ocean and 3-ocean aged sockeye salmon in the Hugh Smith Lake escapement, 1980–2009.

DISCUSSION

In 2009, the weir count of 9,483 adult sockeye salmon met the optimal escapement goal for Hugh Smith Lake sockeye salmon exclusively with wild fish for the fourth time in the past five years (Figure 5). The final age class of fish from the pen-reared sockeye salmon stocking program returned to Hugh Smith Lake in 2007, making 2009 only the second year in over two decades where the total escapement was composed entirely of wild, naturally produced sockeye salmon. The optimal escapement goal, which included fish returning from the stocking program, has now been met in six out of the last seven years. The only recent escapement below the escapement goal range occurred in 2008, which was an extremely poor year for sockeye salmon throughout Southeast Alaska (Eggers and Heinl 2008, Piston 2009).

Since de-listing Hugh Smith Lake sockeye salmon as a stock of management concern in 2006, ADF&G has continued to manage the District 1 purse seine and gillnet fisheries in a manner consistent with the Hugh Smith Lake Sockeye Salmon Action Plan (Final Report to the Board of Fish, RC-106, February 2003). If inseason escapement projections were below the lower bound of the optimal escapement goal of 8,000–18,000 adult sockeye salmon in statistical weeks 29 to 33 (approximately mid-July to mid-August), fishing area in sub-districts 101-11 and 101-23, near the mouth of Boca de Quadra, was reduced to allow additional sockeye salmon to pass through the fisheries. No focused area closures were implemented in 2009 as inseason escapement projections were above the lower threshold of the escapement goal throughout the season.

Fishing effort in the District 101-23 purse seine fishery and the District 101-11 drift gillnet fishery remained near the recent 10-year average (Figure 8). The 2009 sockeye salmon harvest of 4,200 fish in the District 101-23 purse seine fishery was below the recent 10-year average harvest of 6,350 fish (range=152 to 17,900 fish). Similarly, the District 101-11 drift gillnet fishery harvest of 70,000 sockeye salmon was just under the recent 10-year average of 95,000 fish. The District 101-11 drift gillnet fishery was open from June 21 to September 29 with 15 consecutive weeks of fishing and no area or time restrictions. The District 101 purse seine fishery also proceeded as scheduled from July 5 to August 28 with no area restrictions near the mouth of Boca de Quadra.

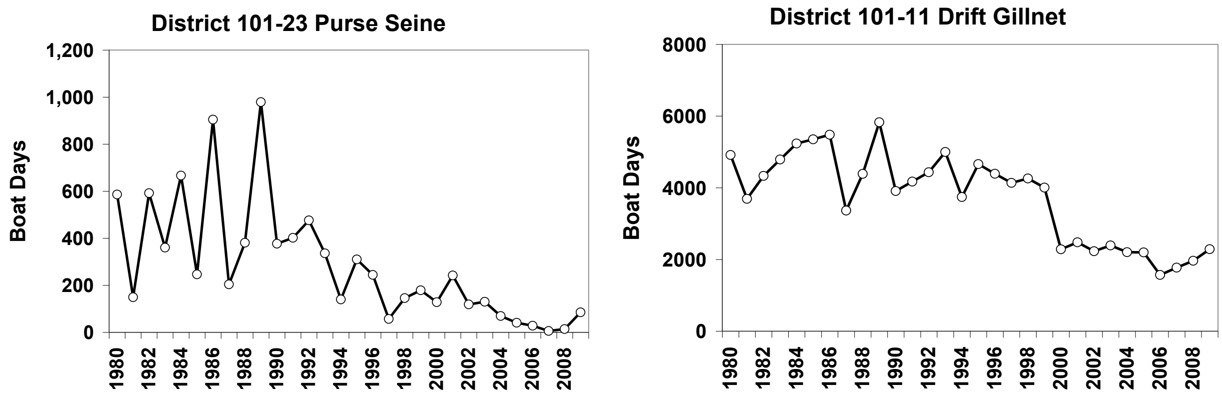

Figure 8.–Fishing effort in boat days for the District 101-23 purse seine fishery and the District 101-11 gillnet fishery, 1980–2009.

Scale pattern analysis of the adult sockeye salmon scale samples revealed a large number of 2-ocean fish in the escapement. Excluding the 2002–2006 time period, when large numbers of stocked sockeye salmon returned as 2-ocean fish, the approximately 4,000 2-ocean fish in 2009 was the second highest escapement for that age class since 1980. From 1980–2001, there were six years with numbers of 2-ocean fish in the escapement in excess of 2,500 fish (Figure 7). Estimated numbers of 3-ocean fish in the following year's escapements for those six years averaged 25,000 fish, with a range of 6,300 to 62,500 fish. However, the 2007 estimated escapement of 2,800 2-ocean fish was followed by very low numbers of 3-ocean fish in 2008—a year when sockeye salmon escapements were extremely poor throughout Southeast Alaska (Eggers et al. 2009). Although strong returns of 2-ocean fish have often been followed by strong returns of 3-ocean fish in the following year, that pattern has not held in all years, making a prediction for strong returns of 3-ocean fish in 2010 tentative at best.

From 2003–2007, total escapements at Hugh Smith Lake were well above the upper bounds of the optimal escapement goal range of 8,000–18,000 adults, but large proportions of the escapements were comprised of stocked fish returning from the net pen rearing program. Wild sockeye salmon made up only 38% of the total escapement on average during those years and many of the stocked fish in the escapement milled near the outlet of the lake and attempted to spawn in unsuitable habitat (Geiger et al. 2005, Piston et al. 2007, Piston 2008). From 2003–2007, 3,446 carcasses washed up on the adult weir at the outlet of the lake, representing approximately 40% of the recoveries for the mark-recapture study. The presence of large numbers of spawning fish at the outlet of the lake and carcasses washed up on the weir was an artifact of pen-reared fish homing to the net pen holding area near the outlet of the lake and was not something we had observed in years prior to the pre-smolt program. In 2008 and 2009, we observed little evidence of fish spawning near the outlet of the lake and only eight sockeye salmon carcasses washed up on the weir in those two years combined, indicating that the thousands of stocked fish attempting to spawn at the outlet of the lake from 2003–2005 likely experienced little spawning success.

Although all of the egg takes for the pen-rearing pre-smolt program were taken from Buschmann Creek, stocked fish that reached the two primary spawning tributaries at the head of the lake entered Cobb Creek in large numbers. For example, since the first 2-ocean fish from the stocking program returned in 2002 until the final return of 3-ocean fish in 2007, an average of 65% of the escapement in Cobb Creek was composed of stocked fish, compared to only 21% of the escapement at Buschmann Creek. Additionally, peak foot survey estimates from Cobb Creek were typically larger than estimates from Buschmann Creek between 2003 and 2007, e.g., in 2006 the peak count in was 3,250 in Cobb Creek versus 2,526 in Buschmann Creek and in 2007 the peak count was nearly 4,000 in Cobb Creek versus 1,900 in Buschmann Creek. Despite a high, but unknown, proportion of the total escapement spawning in Cobb Creek from 2003–2007, escapement counts were very low in Cobb Creek in 2008 and 2009 in comparison to Buschmann Creek counts. The peak survey estimate at Cobb Creek was less than 10% of the peak survey estimate at Buschmann Creek in 2009 (Table 3 and 4). This suggests that stocked fish spawning in Cobb Creek may also have experienced poor spawning success. In addition, the continued stability of sockeye salmon smolt weir counts at levels reached prior to the large escapements of stocked fish lends further support to the idea that many of the stocked fish that returned from 2002 to 2007 did not contribute to natural production within the system (Figure 9).

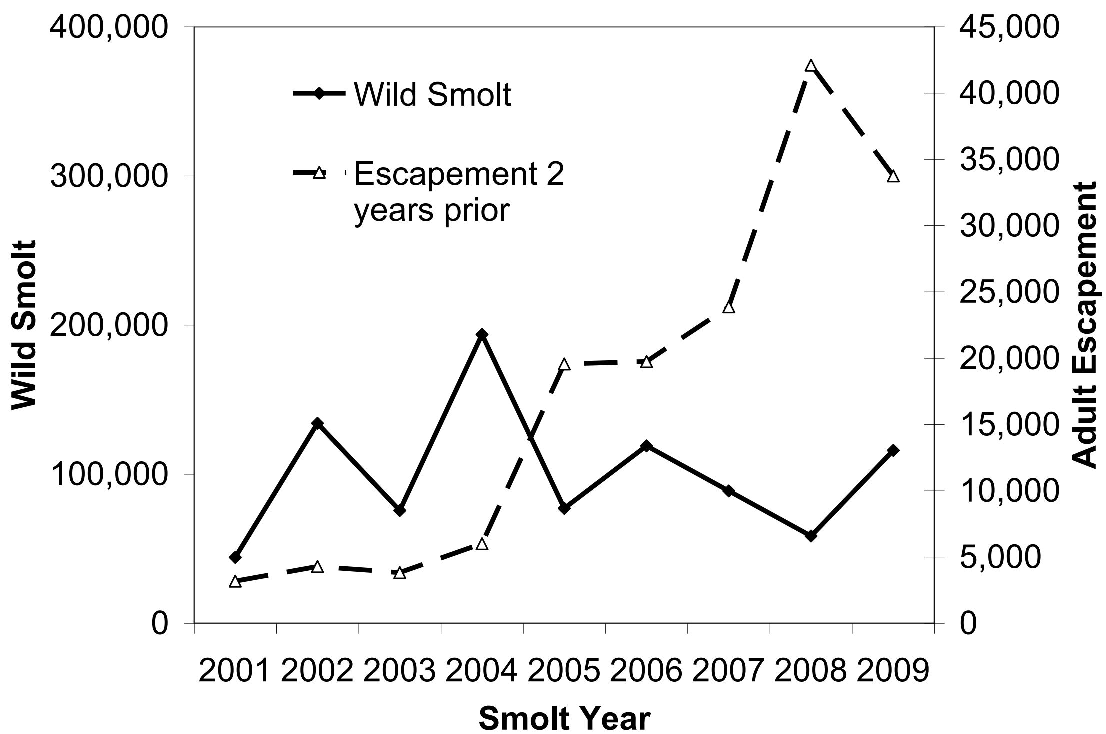

Figure 9.–Sockeye salmon smolt weir counts plotted against adult escapement two years prior, 2001–2009.

Over the years, modifications have been made to adult weir operations to minimize stress on the fish returning to Hugh Smith Lake. Our primary focus in recent years has been to reduce handling of fish at the weir and to ensure that returning fish are not held up unnecessarily behind the weir where they are vulnerable to predation. Prior to 2003, all fish were manually dip-netted out of the trap on the upstream side of the weir for visual identification and enumeration. A secondary fish passing station was designed in 2003 to allow for free passage of fish through the weir. Prior to August, a large proportion of the fish counted through the weir were passed freely through the pickets at the counting station, but once coho salmon began returning in early August we reverted back to dipnetting fish from the trap as it was important to visually examine 100% of the coho salmon for adipose clips, which indicated the presence of a coded-wire tag. In 2007, we built a secondary trap designed to allow free passage of fish into the lake, while allowing us to quickly close the trap when a coho salmon entered. We monitored the secondary trap with a video camera so that in the event we failed to stop a coho salmon we were still able to identify it as adipose-clipped or unclipped by reviewing the video recording. Since 2007, the modified trap design has allowed us to continue passing a large portion of the sockeye salmon freely through the pickets throughout the season while continuing to meet the goals of the ongoing coho salmon study at the lake. The modified fish passing station and use of video recording equipment has significantly reduced the number of fish that need to be physically handled at the weir, resulting in reduced stress for fish passing the weir and decreased holding time behind the weir during times of exceptionally large fish movements. In addition, the reduced handling and dipnetting of fish has reduced the physical challenges for fishery technicians working the weir, making muscle strains and other stress injuries less likely.

Another method that has been used at Hugh Smith Lake since at least the mid-1990s to reduce the incidence of fish being held up behind the weir structure is the application of 4–6 mil plastic sheeting to the upstream face of the weir to concentrate stream flow through the fish passing station and trap during periods of low water flow. The sudden pulse of water through the passing station and trap typically causes most of the fish holding behind the weir to align with the main flow and move through the counting station or into the trap relatively quickly after the plastic sheeting is applied. Typical low summer water flows allow the use of plastic sheeting through most of the season. During high water periods, the use of plastic sheeting on the face of the weir is not particularly effective because of the difficulty in funneling the main flow through specific areas of the weir and the potential stress induced on the weir structure. This strategy has proven very effective and reduces predation by otters and black bears that have access to sockeye salmon congregating in the shallow pool below the weir. The use of plastic sheeting and the more efficient fish passing station has resulted in very few fish being held up at the weir for extended periods in recent years. Most fish make it past the weir structure soon after entering the creek, although some degree of migratory delay may still occur on days of extremely heavy fish passage.

Over the course of the winter of 2008–2009, several stream channel changes occurred in Buschmann Creek. Since conducting an initial habitat inventory in 2004 (Piston et al. 2006), the spawning habitat in Buschmann Creek has been relatively stable, with the most significant changes occurring within the Beaver Pond Channel where several beaver dams have been repeatedly washed out and rebuilt (Figure 3; Piston 2008). In 2009, most of the flow from the Bushmann Creek Main Channel stayed within that channel and water flow into the Hatchery Channel and Side Channel C was reduced compared to recent years (Figure 3). Field crews noted a new beaver dam at the mouth of Hatchery Channel in late June and indicated that flow was greatly reduced in this area and possibly dried up at times. Stream surveys yielded no fish counts along Hatchery Channel in 2009, indicating sockeye were unable or unwilling to utilize this area. Although significant numbers of fish have spawned in the Hatchery Channel in recent years, it is not clear whether the shift in stream channels will negatively affect spawning success due to reduced habitat availability, or if spawning conditions will be improved by increased flows through the Buschmann Creek Main Channel where spawner density is typically highest. In years where water flow is divided between the Hatchery Channel, Side Channel C, and the Main Channel (Figure 3), water levels in the Main Channel can become very low, leaving spawners more vulnerable to predation, even when overall flow from the drainage may be at average levels. Additional changes occurred in the Beaver Pond Channel, where the beaver dams in the lower channel were breeched and fish were reported further upstream and in greater numbers than they are typically observed. Although additional spawning habitat became accessible in the Beaver Pond Channel, the changes may be temporary if beavers repair the dams near the mouth of the channel as they have in the past, so improved accessibility in 2009 may have little long-term impact.

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APPENDICES

The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week, for smolt and adults, were calculated using equations from Cochran (1977; pages 52, 107-108, and 142-144).

Let

h	=	index of the stratum (week),
j	=	index of the age class,
p_{hj}	=	proportion of the sample taken during stratum h that is age j,
n_h	=	number of fish sampled in week h, and
n_{hj}	=	number observed in class j, week h.

Then the age distribution was estimated for each week of the escapement in the usual manner:

$$\hat{p}_{hj} = n_{hj} / n_h \; . \qquad (1)$$

If N_h equals the number of fish in the escapement in week h, standard errors of the weekly age class proportions are calculated in the usual manner (Cochran 1977, page 52, equation 3.12):

$$SE(\hat{p}_{hj}) = \sqrt{\left[\frac{(\hat{p}_{hj})(1-\hat{p}_{hj})}{n_h - 1}\right][1 - n_h / N_h]} \; . \qquad (2)$$

The age distributions for the total escapement were estimated as a weighted sum (by stratum size) of the weekly proportions. That is,

$$\hat{p}_j = \sum_h p_{hj} (N_h / N), \qquad (3)$$

such that N equals the total escapement. The standard error of a seasonal proportion is the square root of the weighted sum of the weekly variances (Cochran 1977, pages 107–108):

$$SE(\hat{p}_j) = \sqrt{\sum_j^h [SE(\hat{p}_{hj})]^2 (N_h / N)^2} \; . \qquad (4)$$

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, were calculated using the following equations from Cochran (1977, pages 142-144) for estimating means over subpopulations. That is, let i equal the index of the individual fish in the age-sex class j, and y_{hij} equal the length of the ith fish in class j, week h, so that,

$$\hat{\bar{Y}}_j = \frac{\sum_h (N_h / n_h) \sum_i y_{hij}}{\sum_h (N_h / n_h) n_{hj}} \text{, and} \qquad (5)$$

$$\hat{V}\left(\hat{\bar{Y}}_j\right) = \frac{1}{\hat{N}_j^2} \sum_h \frac{N_h^2 (1 - n_h / N_h)}{n_h (n_h - 1)} \left[\sum_i \left(y_{hij} - \bar{y}_{hj}\right)^2 + n_{hj}\left(1 - \frac{n_{hj}}{n_h}\right)\left(\bar{y}_{hj} - \hat{\bar{Y}}_j\right)^2 \right].$$

APPENDIX B
HUGH SMITH LAKE SOCKEYE SALMON ESCAPEMENT AND RUN TIMING

Appendix B1.–Hugh Smith Lake sockeye salmon escapement and run timing, 1967–1985.

Year	**1967**	**1968**	**1969**	**1970**	**1971**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**
Weir Count	6,754	1,617	10,357	8,755	22,096	12,714	15,545	57,219	10,429	16,106	12,245
Total Escapement[a]								57,219	10,429	16,106	12,245
Weir Mortalities	NA	NA	NA	NA	NA	NA	NA	81	45	134	201
Adults used for egg takes	0	0	0	0	0	0	0	0	0	439	798
Spawning Escapement[b]	NA	NA	NA	NA	NA	NA	NA	57,138	10,384	15,533	11,246
Jacks (not included in weir count)											
Starting Date	1-Jun	13-Jun	11-Jun	9-Jun	20-Jun	5-Jun	7-Jun	4-Jun	30-May	1-Jun	1-Jun
Ending Date	3-Sep	21-Aug	14-Aug	1-Sep	22-Aug	4-Oct	8-Sep	27-Nov	30-Nov	26-Nov	11-Nov
Days Elapsed	94	69	64	84	63	121	93	176	184	178	163
Date of First Sockeye	13-Jun	14-Jun	11-Jun	11-Jun	20-Jun	6-Jun	8-Jun	7-Jun	1-Jun	6-Jun	5-Jun
Date of Last Sockeye	3-Sep	21-Aug	14-Aug	1-Sep	22-Aug	4-Oct	8-Sep	25-Oct	25-Oct	19-Nov	29-Oct
Days Elapsed for sockeye caught	82	68	64	82	63	120	92	140	146	166	146
10th Percentile Run Date	22-Jun	2-Jul	26-Jun	26-Jun	1-Jul	4-Jul	28-Jun	20-Jun	11-Jul	14-Jul	12-Jul
25th Percentile Run Date	28-Jun	11-Jul	9-Jul	6-Jul	9-Jul	20-Jul	7-Jul	29-Jun	17-Jul	26-Jul	25-Jul
50th Percentile Run Date	7-Jul	15-Aug	20-Jul	27-Jul	20-Jul	6-Aug	27-Jul	9-Jul	11-Aug	8-Aug	23-Aug
75th Percentile Run Date	18-Jul	19-Aug	7-Aug	6-Aug	19-Aug	26-Aug	24-Aug	18-Jul	4-Sep	26-Aug	2-Sep
90th Percentile Run Date	28-Jul	21-Aug	9-Aug	13-Aug	20-Aug	9-Sep	3-Sep	7-Aug	24-Sep	10-Sep	13-Sep

[a] The total escapement equals the weir count, 1967–1985. Separate counts of jacks were not kept from 1967 to 1985, so these weir counts include an unknown number of jacks.

[b] The spawning escapement equals the total estimated escapement minus the weir mortalities (coded-wire-tagged fish) and fish killed for egg takes.

Appendix B2.–Hugh Smith Lake sockeye salmon escapement and run timing, 1986–1997.

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Weir Count	2,312	33,097	5,056	6,513	1,285	5,885	65,737	11,312	8,386	3,424	7,123	12,182
Total Escapement[a]	6,968	33,097	5,056	6,513	1,285	5,885	65,737	13,532	8,992	3,452	7,123	12,182
Weir Mortalities	12	0	28	32	28	33	151	278	42	11	57	28
Adults used for egg takes	619	1,902	424	1,547	0	357	178	1,460	763	312	513	0
Spawning Escapement[b]	6,337	31,195	4,604	4,934	1,257	5,495	65,408	11,794	8,187	3,129	6,553	12,154
Jacks (not included in weir count)												
Starting Date	17-Jun	3-Jun	5-Jun	3-Jun	8-Jun	17-Jun	16-Jun	17-Jun	20-Jun	17-Jun	17-Jun	18-Jun
Ending Date	29-Oct	21-Oct	22-Oct	25-Oct	31-Oct	9-Oct	25-Oct	4-Nov	1-Nov	3-Nov	4-Nov	5-Nov
Days Elapsed	134	140	139	144	145	114	131	140	134	139	140	140
Date of First Sockeye	18-Jun	8-Jun	12-Jun	11-Jun	13-Jun	19-Jun	16-Jun	20-Jun	20-Jun	19-Jun	20-Jun	18-Jun
Date of Last Sockeye	3-Oct	4-Oct	16-Oct	18-Oct	21-Oct	11-Oct	18-Oct	3-Nov	26-Oct	1-Nov	20-Oct	1-Nov
Days Elapsed for sockeye caught	107	118	126	129	130	114	124	136	128	135	122	136
10th Percentile Run Date	11-Jul	18-Jul	19-Jul	30-Jul	8-Jul	22-Jul	12-Jul	2-Jul	20-Jul	7-Jul	25-Jul	3-Jul
25th Percentile Run Date	15-Jul	20-Jul	24-Jul	5-Aug	23-Jul	29-Jul	19-Jul	16-Jul	1-Aug	17-Jul	11-Aug	16-Jul
50th Percentile Run Date	20-Jul	4-Aug	9-Aug	10-Aug	27-Aug	21-Aug	27-Jul	30-Jul	23-Aug	29-Jul	19-Aug	25-Jul
75th Percentile Run Date	28-Jul	30-Aug	25-Aug	14-Aug	7-Sep	12-Sep	29-Jul	14-Aug	26-Aug	9-Aug	3-Sep	2-Aug
90th Percentile Run Date	8-Aug	31-Aug	1-Sep	22-Aug	16-Sep	22-Sep	11-Aug	31-Aug	3-Sep	21-Aug	13-Sep	15-Aug

[a] The total escapement equals the mark-recapture estimate (1986, 1993, 1994, 1995) plus weir mortalities, or the weir count. (Data used to calculate a Petersen estimate in 1986 are not available). Separate counts of jacks were not kept from 1986 to 1997, so these weir counts include an unknown number of jacks.

[b] The spawning escapement equals the total estimated escapement minus the weir mortalities (coded-wire-tagged fish) and fish killed for egg takes.

Appendix B3.–Hugh Smith Lake sockeye salmon escapement and run timing, 1998–2009.

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Weir Count	1,138	3,174	4,281	3,665	6,166	19,588	19,930	24,108	42,529	34,077	3,590	9,483
Total Escapement[a]	1,138	3,174	4,281	3,825	6,166	19,588	19,930	24,108	42,529	34,077	3,590	9,483
Weir Mortalities	23	20	12	6	0	20	196	236	417	334	2	0
Adults used for egg takes	218	276	280	268	286	0	0	0	0	0	0	0
Spawning Escapement[b]	897	2,878	3,989	3,551	5,880	19,568	19,734	23,872	42,112	33,743	3,588	9,483
Jacks (not included in weir count)					167	1,356	147	331	4	236	260	301
Starting Date	17-Jun	16-Jun	17-Jun	16-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	16-Jun
Ending Date	11-Nov	8-Nov	11-Nov	11-Nov	4-Nov	7-Nov	7-Nov	4-Nov	7-Nov	4-Nov	3-Nov	8-Nov
Days Elapsed	147	145	147	148	140	146	142	143	143	140	139	145
Date of First Sockeye	19-Jun	22-Jun	19-Jun	19-Jun	19-Jun	19-Jun	18-Jun	19-Jun	19-Jun	18-Jun	19-Jun	18-Jun
Date of Last Sockeye	12-Oct	4-Oct	27-Oct	6-Oct	17-Oct	2-Nov	31-Oct	22-Oct	3-Nov	26-Oct	28-Oct	5-Oct
Days Elapsed for sockeye caught	115	104	130	109	120	136	135	125	137	130	131	110
10th Percentile Run Date	8-Jul	7-Jul	29-Jun	2-Jul	10-Jul	2-Aug	8-Jul	17-Jul	1-Aug	19-Jul	16-Jul	4-Jul
25th Percentile Run Date	21-Jul	15-Jul	7-Jul	18-Jul	4-Aug	17-Aug	4-Aug	31-Jul	4-Aug	16-Aug	26-Jul	10-Jul
50th Percentile Run Date	30-Jul	31-Jul	20-Jul	17-Aug	7-Aug	21-Aug	6-Aug	20-Aug	9-Aug	28-Aug	31-Jul	23-Jul
75th Percentile Run Date	10-Aug	15-Aug	30-Jul	22-Aug	9-Aug	28-Aug	29-Aug	26-Aug	15-Aug	1-Sep	14-Aug	11-Aug
90th Percentile Run Date	18-Aug	22-Aug	6-Aug	23-Aug	12-Aug	2-Sep	2-Sep	3-Sep	26-Aug	7-Sep	24-Aug	13-Aug

[a] The total escapement equals the mark-recapture estimate (2001) plus weir mortalities, or the weir count. Separate counts of jacks were not kept from 1998 to 2000, so these weir counts include an unknown number of jacks.

[b] The spawning escapement equals the total estimated escapement minus the weir mortalities (coded-wire-tagged fish) and fish killed for egg takes.

Appendix C.–Mark-recapture escapement estimates for Hugh Smith Lake sockeye salmon, 1992–2009. Boldface estimates were used as the official escapement estimate for that year.

Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Live Weir Count [a]	**65,586**	11,034	8,344	3,413	**7,066**	**12,154**	**1,115**	**3,154**	**4,269**	3,629	**5,999**	**19,568**	**19,734**	**23,872**	**42,112**	**33,743**	**3,588**	**9,483**
Proportion Marked	36%	99%	97%	100%	99%	67%	67%	67%	67%	50%	50%	10%	10%	10%	10%	10%	10%	10%
Number Marked	23,790	10,973	8,126	3,396	6,995	8,100	745	2,103	2,846	1,807	2,999	1,945	1,979	2,278	4,208	3,414	358	949
Number Sampled for Marks	1,974	2,377	1,152	1,028	374	934	226	323	443	484	908	2,057	1,547	1,244	2,187	1,764	659	1,271
Number of Marks Recovered	814	2,029	1,041	1,006	369	638	157	221	299	230	449	194	136	115	229	176	50	123
Pooled Petersen Estimate[b,c]	57,652	12,854	8,992	3,470	7,090	11,853	1,071	3,070	4,213	**3,789**	6,059	20,537	22,372	24,459	40,039	34,053	4,645	9,744
se	1,520	99	81	13	41	253	42	109	131	168	187	1,324	1,754	2,098	2,423	2,357	573	772
+/-95% CI	2,979	194	159	25	80	496	82	214	257	329	367	2,595	3,438	4,112	4,749	4,621	1,123	1,513
CV	3%	1%	1%	0%	1%	2%	4%	4%	3%	4%	3%	6%	8%	9%	6%	7%	12%	8%
ML Darroch Estimate[b]	Failed	**13,254**	Failed	Failed	Failed	12,312	1,015	3,038	4,050	-	Failed	19,147	21,950					
se		134				849	46	138	145			1,526	1,991					
+/-95% CI		263				1,664	90	270	284			2,990	4,000					
CV		1%				7%	5%	5%	4%			8%	9%					
ML Darroch - Pooled Strata[d]	58,712	-	**8,925**	**3,441**	7,090	-	-	-	-	3,641	6,047							
se	1,823		77	70	42					205	194							
+/-95% CI	3,573		151	137	82					402	380							
CV	3%		1%	2%	1%					6%	3%							

[a] The weir count used for the mark-recapture calculations was the number of live fish (weir count minus weir mortalities) passed through the weir.

[b] Pooled Petersen, and ML Darroch estimates and their standard errors were calculated using Stratified Population Analysis Software. Release data were stratified into three release periods and recovery data were stratified by recovery days.

[c] Chi-square tests for goodness of fit and complete mixing in 1993, 1994, and 1995 were highly significant and suggest that the ML Darroch estimates should be used rather than a Pooled Petersen estimate.

[d] When ML Darroch estimates failed to converge, data were pooled until an estimate was obtained.

Appendix D.–Age distribution of the Hugh Smith Lake sockeye salmon escapement based on scale pattern analysis, weighted by week of escapement, 1980–2009.

Return Year		**0.1**	**1.1**	**2.1**	**3.1**	**0.2**	**1.2**	**2.2**	**3.2**	**0.3**	**1.3**	**2.3**	**3.3**	**1.4**	**2.4**	**1.5**	**2.5**	**Total**
1980	Number by Age Class		37				1,055	113			9,380	2,129						12,714
	SE of Number		0				16	1			150	39						
	Proportion by Age Class		0.3%				8.3%	0.9%			73.8%	16.7%						
	SE of Proportion		0.0%				0.1%	0.0%			1.2%	0.3%						
	Sample Size		3				72	12			719	175						981
1981	Number by Age Class		250				7,216	1,826			4,598	1,655						15,545
	SE of Number		1				114	32			65	30						
	Proportion by Age Class		1.6%				46.4%	11.7%			29.6%	10.6%						
	SE of Proportion		0.0%				0.7%	0.2%			0.4%	0.2%						
	Sample Size		19				502	149			338	137						1,145
1982	Number by Age Class						1,613	805		12	52,124	2,665						57,219
	SE of Number						17	7		0	183	44						
	Proportion by Age Class						2.8%	1.4%		0.0%	91.1%	4.7%						
	SE of Proportion						0.0%	0.0%		0.0%	0.3%	0.1%						
	Sample Size						174	122		1	2,305	407						3,009
1983	Number by Age Class		14	8			1,375	495		12	5,501	2,843		182				10,429
	SE of Number		0	0			20	6		0	103	44		2				
	Proportion by Age Class		0.1%	0.1%			13.2%	4.7%		0.1%	52.7%	27.3%		1.7%				
	SE of Proportion		0.0%	0.0%			0.2%	0.1%		0.0%	1.0%	0.4%		0.0%				
	Sample Size		1	1			157	57		2	565	301		23				1,107
1984	Number by Age Class		9				966	551			10,436	4,144						16,106
	SE of Number		0				14	6			95	72						
	Proportion by Age Class		0.1%				6.0%	3.4%			64.8%	25.7%						
	SE of Proportion		0.0%				0.1%	0.0%			0.6%	0.4%						
	Sample Size		1				149	56			1,007	378						1,591
1985	Number by Age Class			15			76	43			8,935	2,997	13	74	70		23	12,245
	SE of Number			0			1	0			104	55	0	1	0		0	
	Proportion by Age Class			0.1%			0.6%	0.3%			73.0%	24.5%	0.1%	0.6%	0.6%		0.2%	
	SE of Proportion			0.0%			0.0%	0.0%			0.9%	0.4%	0.0%	0.0%	0.0%		0.0%	
	Sample Size			1			10	6			856	279	2	6	7		3	1,170
1986	Number by Age Class		5			4	5,076	780			745	305		49		5		6,968
	SE of Number		0			0	20	11			4	3		0		0		
	Proportion by Age Class		0.1%			0.1%	72.8%	11.2%			10.7%	4.4%		0.7%		0.1%		
	SE of Proportion		0.0%			0.0%	0.3%	0.2%			0.1%	0.0%		0.0%		0.0%		
	Sample Size		1			1	1,389	191			195	77		13		1		1,868

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Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
1987	Number by Age Class		147	130			626	1,030	24		29,329	1,733	61	17				33,097
	SE of Number		1	1			2	6	0		221	27	0	0				
	Proportion by Age Class		0.4%	0.4%			1.9%	3.1%	0.1%		88.6%	5.2%	0.2%	0.1%				
	SE of Proportion		0.0%	0.0%			0.0%	0.0%	0.0%		0.7%	0.1%	0.0%	0.0%				
	Sample Size		9	18			66	132	4		3,374	278	6	1				3,888
1988	Number by Age Class		5	3			1,907	1,237			1,054	782	2	67				5,056
	SE of Number		0	0			13	9			6	4	0	0				
	Proportion by Age Class		0.1%	0.1%			37.7%	24.5%			20.8%	15.5%	0.0%	1.3%				
	SE of Proportion		0.0%	0.0%			0.3%	0.2%			0.1%	0.1%	0.0%	0.0%				
	Sample Size		3	2			1,076	727			624	499	1	46				2,978
1989	Number by Age Class						163	52	1		5,808	486	1		2			6,513
	SE of Number						1	1	0		32	7	0		0			
	Proportion by Age Class						2.5%	0.8%	0.0%		89.2%	7.5%	0.0%		0.0%			
	SE of Proportion						0.0%	0.0%	0.0%		0.5%	0.1%	0.0%		0.0%			
	Sample Size						116	24	1		1,489	184	1		1			1,816
1990	Number by Age Class		12	1			52	38			658	495	1	27				1,285
	SE of Number		0	0			0	0			5	9	0	0				
	Proportion by Age Class		0.9%	0.1%			4.1%	3.0%			51.2%	38.5%	0.1%	2.1%				
	SE of Proportion		0.0%	0.0%			0.0%	0.0%			0.4%	0.7%	0.0%	0.0%				
	Sample Size		8	1			39	29			537	294	1	24				933
1991	Number by Age Class		2	26	4		1,588	2,028	2		781	1,442			13			5,885
	SE of Number		0	0	0		7	20	0		2	8			0			
	Proportion by Age Class		0.0%	0.4%	0.1%		27.0%	34.5%	0.0%		13.3%	24.5%			0.2%			
	SE of Proportion		0.0%	0.0%	0.0%		0.1%	0.3%	0.0%		0.0%	0.1%			0.0%			
	Sample Size		2	11	1		1,274	1,103	1		629	998			8			4,027
1992	Number by Age Class		3	3			1,587	1,262	15		60,690	1,824		336	15			65,737
	SE of Number		0	0			22	31	0		589	34		2	0			
	Proportion by Age Class		0.0%	0.0%			2.4%	1.9%	0.0%		92.3%	2.8%		0.5%	0.0%			
	SE of Proportion		0.0%	0.0%			0.0%	0.0%	0.0%		0.9%	0.1%		0.0%	0.0%			
	Sample Size		1	1			63	105	1		914	135		2	2			1,224
1993	Number by Age Class			13			1,137	1,916	10		3,055	7,038	66	285	13			13,532
	SE of Number			0			25	39	0		50	135	1	5	0			
	Proportion by Age Class			0.1%			8.4%	14.2%	0.1%		22.6%	52.0%	0.5%	2.1%	0.1%			
	SE of Proportion			0.0%			0.2%	0.3%	0.0%		0.4%	1.0%	0.0%	0.0%	0.0%			
	Sample Size			2			62	163	1		279	564	2	31	1			1,105

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Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
1994	Number by Age Class		51	41			572	625	6		6,546	1,079		66	5	2		8,992
	SE of Number		0	0			5	7	0		106	11		0	0	0		
	Proportion by Age Class		0.6%	0.5%			6.4%	7.0%	0.1%		72.8%	12.0%		0.7%	0.1%	0.0%		
	SE of Proportion		0.0%	0.0%			0.1%	0.1%	0.0%		1.2%	0.1%		0.0%	0.0%	0.0%		
	Sample Size		12	13			148	91	2		966	243		18	2	1		1,496
1995	Number by Age Class			25			902	451			802	1,226		44	1			3,452
	SE of Number			0			14	6			13	24		0	0			
	Proportion by Age Class			0.7%			26.1%	13.1%			23.2%	35.5%		1.3%	0.0%			
	SE of Proportion			0.0%			0.4%	0.2%			0.4%	0.7%		0.0%	0.0%			
	Sample Size			16			299	133			263	408		13	1			1,133
1996	Number by Age Class		12				1,012	1,654	6		3,519	904			16			7,123
	SE of Number		0				30	79	0		93	24			1			
	Proportion by Age Class		0.2%				14.2%	23.2%	0.1%		49.4%	12.7%			0.2%			
	SE of Proportion		0.0%				0.4%	1.1%	0.0%		1.3%	0.3%			0.0%			
	Sample Size		2				97	76	1		287	70			1			534
1997	Number by Age Class		18				249	403			10,791	664	20	35				12,180
	SE of Number		0				5	4			121	20	0	0				
	Proportion by Age Class		0.1%				2.0%	3.3%			88.6%	5.5%	0.2%	0.3%				
	SE of Proportion		0.0%				0.0%	0.0%			1.0%	0.2%	0.0%	0.0%				
	Sample Size		1				13	22			580	37	1	2				656
1998	Number by Age Class		27	9		3	75	49			576	332		66				1,138
	SE of Number		4	1		0	4	2			26	21		4				
	Proportion by Age Class		2.4%	0.8%		0.3%	6.6%	4.3%			50.6%	29.2%		5.8%				
	SE of Proportion		0.3%	0.1%		0.0%	0.3%	0.2%			2.3%	1.9%		0.3%				
	Sample Size		2	3		1	9	7			81	32		5				140
1999	Number by Age Class			29			1,658	538			573	363		6	7			3,174
	SE of Number			1			35	11			13	7		0	0			
	Proportion by Age Class			0.9%			52.2%	17.0%			18.1%	11.4%		0.2%	0.2%			
	SE of Proportion			0.0%			1.1%	0.3%			0.4%	0.2%		0.0%	0.0%			
	Sample Size			4			245	77			81	53		1	1			462
2000	Number by Age Class		14		13		918	302			2,251	769	14					4,281
	SE of Number		0		0		21	5			52	22	0					
	Proportion by Age Class		0.3%		0.3%		21.4%	7.1%			52.6%	18.0%	0.3%					
	SE of Proportion		0.0%		0.0%		0.5%	0.1%			1.2%	0.5%	0.0%					
	Sample Size		1		1		94	33			257	70	1					457

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Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2001	Number by Age Class	7	60			6	162	71			2,908	598		7	6			3,825
	SE of Number	0	1			0	13	1			43	9		0	0			
	Proportion by Age Class	0.2%	1.6%			0.2%	4.2%	1.9%			76.0%	15.6%		0.2%	0.2%			
	SE of Proportion	0.0%	0.0%			0.0%	0.3%	0.0%			1.1%	0.2%		0.0%	0.0%			
	Sample Size	1	9			1	25	14			591	120		1	1			763
2002	Number by Age Class		6	21			3,981	564			1,318	263		13				6,166
	SE of Number		0	1			58	11			21	6		0				
	Proportion by Age Class		0.1%	0.3%			64.6%	9.2%			21.4%	4.3%		0.2%				
	SE of Proportion		0.0%	0.0%			0.9%	0.2%			0.3%	0.1%		0.0%				
	Sample Size		1	3			582	77			197	36		2				898
2003	Number by Age Class		42	67		14	10,028	840	18	136	7,385	1,059						19,588
	SE of Number		2	3		0	144	24	0	0	112	8						
	Proportion by Age Class		0.2%	0.3%		0.1%	51.2%	4.3%	0.1%	0.7%	37.7%	5.4%						
	SE of Proportion		0.0%	0.0%		0.0%	0.7%	0.1%	0.0%	0.0%	0.6%	0.0%						
	Sample Size		3	5		1	622	50	1	9	437	65						1,193
2004	Number by Age Class		523	36			8,623	1,695			8,362	690						19,930
	SE of Number		9	1			154	28			145	6						
	Proportion by Age Class		2.6%	0.2%			43.3%	8.5%			42.0%	3.5%						
	SE of Proportion		0.0%	0.0%			0.8%	0.1%			0.7%	0.0%						
	Sample Size		25	2			385	84			387	39						922
2005	Number by Age Class			26			6,696	1,566		18	14,264	1,537						24,108
	SE of Number			0			86	16		0	176	14						
	Proportion by Age Class			0			27.8%	6.5%		0.1%	59.2%	6.4%						
	SE of Proportion			0			0.3%	0.1%		0.0%	0.7%	0.1%						
	Sample Size			2			440	98		1	900	97						1,538
2006	Number by Age Class						20,815	3,467			16,642	1,604						42,529
	SE of Number						572	83			380	45						
	Proportion by Age Class						48.9%	8.2%			39.1%	3.8%						
	SE of Proportion						1.3%	0.2%			0.9%	0.1%						
	Sample Size						314	102			357	46						819
2007	Number by Age Class						2,266	592			25,915	5,304						34,077
	SE of Number						39	9			486	109						
	Proportion by Age Class						6.6%	1.7%			76.0%	15.6%						
	SE of Proportion						0.1%	0.0%			1.4%	0.3%						
	Sample Size						34	11			494	96						635

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Return Year		0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	1.5	2.5	Total
2008	Number by Age Class						1,437	855			708	445		129	16			3,590
	SE of Number						40	19			21	12		2	2			
	Proportion by Age Class						40.0%	23.8%			19.7%	12.4%		3.6%	0.4%			
	SE of Proportion						1.1%	0.5%			0.6%	0.3%		0.1%	0.0%			
	Sample Size						140	90			67	44		13	1			355
2009	Number by Age Class						2,407	1,588			4,397	1,091						9,483
	SE of Number						40	135			80	18						
	Proportion by Age Class						25.4%	16.7%			46.4%	11.5%						
	SE of Proportion						0.4%	0.4%			0.8%	0.2%						
	Sample Size						186	106			342	75						709